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Monitoring, Incentive Contracting, and Accounting Manipulation

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Monitoring, Incentive Contracting, and Accounting Manipulation

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To my parents and my siblings.

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Monitoring, Incentive Contracting, and Accounting Manipulation

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This study examines how a monitoring system that constrains accounting manipulation affects shareholder value and managerial rents. Although it is generally argued that constraining manipulation via monitoring alleviates effort control problems, this study demonstrates that monitoring can make it more, not less, costly to induce high managerial effort. The key intuition is that the optimal contract incentivizes managers to manipulate accounting reports to influence project continuation decisions. More importantly, when manipulation is costly, management's manipulation incentives increase in the level of productive effort. This result implies that allowing accounting manipulation can make it more attractive for managers to exert high productive effort. Consequently, restricting manipulation via monitoring can increase the cost of incentive contracting, which reduces shareholder value. In addition, monitoring discourages managers from engaging in costly manipulation activities and thus can increase managerial rents. The analysis also shows that monitoring

can increase shareholder value and managerial rents simultaneously, suggesting that shareholders and managers do not always disagree on the optimal monitoring system.

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Chapter 1

Introduction

Accounting manipulation is generally viewed as an action that benefits managers at the expense of shareholders. One aspect of this argument suggests that accounting manipulation exacerbates effort control problems (e.g. Feltham and Xie 1994, Goldman and Slezak 2006). Intuitively, accounting manipulation makes it more difficult to induce high managerial effort because managers can manipulate information to achieve desirable performance measurement reports instead of exerting high effort to improve actual performance. Constraining manipulation via monitoring therefore makes it easier to induce high managerial effort and reduces the cost of incentive contracting. In this study, I demonstrate that, under certain conditions, restricting manipulation via monitoring can make it more difficult to induce high managerial effort. The key driver behind this result is that managers have incentives to manipulate accounting reports to influence project continuation decisions. More importantly, given that manipulation is costly, management's manipulation incentives increase in the level of productive effort. Allowing managers to manipulate the report increases the likelihood they will obtain a bonus, but it increases more quickly when they exert high effort than when they exert low effort. Consequently, constraining manipulation via monitoring can make it less attractive for managers to exert high effort, resulting in an increase in the cost of incentive contracting.

One implication of the finding that monitoring can aggravate effort control problems is that shareholders may not always prefer a strong monitoring system, even when monitoring is costless. In a similar vein, managers may not always prefer a weak monitoring system because monitoring can increase managerial rents. The analysis also shows that a monitoring system that constrains manipulation activities can simultaneously increase both shareholder value and managerial rents, suggesting that shareholders and managers do not always have different preferences for an optimal monitoring system. As a consequence, organizational changes that shift the relative power between managers and shareholders do not necessarily trigger changes in monitoring intensity.

I consider a principal-agent model in which shareholders hire a manager to work on an investment project. At the beginning of the game, shareholders and the manager jointly determine the level of monitoring intensity. Shareholders then offer an incentive contract to induce unobservable managerial effort that improves project quality. At an interim stage, the manager privately observes a signal that provides information about project quality, although this signal is not perfectly accurate. The manager can manipulate this signal by incurring a personal cost, which is determined by the level of manipulation and the intensity of monitoring. Higher-intensity monitoring causes higher marginal cost of manipulation. Shareholders observe a potentially manipulated signal in the form of an interim accounting report and have the right to decide whether to continue or to liquidate the project. If the project is continued, a long-term investment outcome will be realized.

Shareholders rely on interim accounting information to make a project continuation decision. If shareholders could directly observe the interim signal, it would be first-best optimal for them to liquidate the project when the interim signal is unfavorable and to continue it otherwise. Accounting manipulation reduces the efficiency of this project continuation decision because it distorts the quality of interim accounting information. As a consequence, constraining manipulation via monitoring improves the quality of interim accounting information and thus improves shareholders' ability to correctly decide whether to continue or to liquidate the project. Based on this argument, monitoring improves investment efficiency and therefore increases shareholder value.

Although monitoring always improves investment efficiency, its impact on incentive contracts depends on the contracting environment. In the benchmark setting in which investment outcomes are not contractible, the manager is given a bonus when the interim accounting report is favorable. In this case, manipulation and productive effort are substitutes because the likelihood that the manager will manipulate the report decreases as the level of productive effort increases. Therefore, allowing the manager to manipulate the report reduces the manager's incentive to supply high productive effort, resulting in an increase in the cost of incentive contracting as well as an increase in managerial rents. Put differently, constraining manipulation via monitoring reduces the cost of incentive contracting and managerial rents, consistent with the conventional view that monitoring reduces agency conflicts between shareholders and managers.

When investment outcomes can be used for contracting purposes, however, the manager is given a bonus only for long-term success which can be achieved only when the project is continued. As a result, the manager has an incentive to manipulate the interim report to convince shareholders to continue the project. Although managerial effort decreases the likelihood that the manager will manipulate the report, it increases the manipulation level when the manager actually does manipulate the report. This result follows because, when determining the manipulation level, the manager faces a trade-off between the benefit and the cost of manipulation. The expected benefit of manipulation increases in the likelihood of obtaining the bonus if manipulation is successful while the cost of manipulation increases in the level of manipulation. As the productive effort level increases, the likelihood that the project succeeds increases, and the manager's expected benefit from manipulation increases. Therefore, the manager optimally chooses a higher level of manipulation when he exerts high effort than when he exerts low effort. This result implies that allowing manipulation increases the probability that the manager is rewarded a bonus more quickly when he exerts high effort than when he exerts low effort, suggesting that manipulation reduces the bonus required to induce high managerial effort. Nevertheless, manipulation also increases the likelihood that the manager obtains the bonus. I show that when the difference in manipulation incentives between a manager who exerts high and low effort is large or when the equilibrium manipulation level is low, the effect of manipulation in reducing the bonus level dominates its effect in increasing the probability that the manager obtains the bonus such that restricting manipulation via monitoring leads to an increase in expected compensation. In addition, a monitoring system that makes it difficult to manipulate the report benefits the manager because it increases the bonus level as well as discourages him from engaging in manipulation activities, resulting in a reduction in expected manipulation costs. As a consequence, constraining manipulation via monitoring increases managerial rents.

Taken as a whole, these results show that shareholders may find it optimal to implement a weak monitoring system even when there is no direct cost associated with the implementation of a strong monitoring system. When shareholders cannot use long-term investment outcomes for contracting purposes, monitoring always increases shareholder value as it improves investment efficiency and alleviates effort control problems. However, when long-term investment outcomes are contractible, monitoring sometimes decreases shareholder value because it can exacerbate effort control problems and thus increase expected compensation. Similarly, managers may find it optimal to implement a strong monitoring system because monitoring increases managerial rents when investment outcomes are contractible. These results suggest that as the relative degree of managerial influence over a monitoring system increases, the monitoring system can become stronger, not weaker.

In addition, monitoring can increase both shareholder value and managerial rents simultaneously because it reduces the deadweight loss associated with expected manipulation cost and inefficient investment decisions, and this gain is shared between shareholders and managers. Consequently, shareholders and managers do not always have different preferences in terms of optimal monitoring systems. The results of this study also show that shareholder value can be maximized in the presence of high managerial rents, weak monitoring, high manipulation, or high expected compensation, whereas managerial rents can be maximized when expected compensation is low. Finally, a monitoring system that constrains accounting manipulation always decreases the manipulation level but can either increase or decrease the bonus level. Therefore, the relationship between the level of bonus and manipulation incentive can be either positive or negative.

This study proceeds as follows. Chapter 2 discusses prior literature related to this study. Chapter 3 describes the model and assumptions. Chapter 4 shows the effects of monitoring on optimal contracting, expected compensation, and managerial rents when investment outcomes are not contractible while Chapter 5 shows these effects when investment outcomes are contractible. The effect of monitoring on investment efficiency is shown in Chapter 6. Chapter 7 shows the optimal monitoring system given the relative degree of influence over a monitoring system between shareholders and managers. I discuss the empirical implications of the model in Chapter 8. Chapter 9 concludes the study. All proofs are shown in Appendix B.

Chapter 2

Related Literature

In this chapter, I discuss prior research related to this study. One of the key features of the model in the present study is that shareholders use interim information to make a project continuation decision and for incentive contracting. The model used in this study modifies the capital financing model used in Dessi (2005) in which an agent's effort affects investment outcomes and the interim information is used for a project continuation decision as well as for contracting purposes. Dessi (2005) assumes that the interim information is either publicly observable or privately observed by the agent. I modify this assumption by assuming that there is an accounting system that reduces information asymmetry between a principal and an agent. However, this information is not perfectly accurate because of exogenous noise and manipulation incentives. In addition, while Dessi (2005) focuses on deriving optimal financing contracts, the emphasis in this paper is on the effects of constraining manipulation via monitoring on shareholder value and managerial rents.

Prior literature that examines the agency problem and accounting manipulation includes Feltham and Xie (1994), Goldman and Slezak (2006), Crocker and Slemrod (2007), and Laux (2014). Feltham and Xie (1994) consider a setting in which an agent can take productive actions and unproductive actions–both of which affect contractible performance measures while gross payoff is not contractible. They show that an agent's opportunity to take unproductive actions (i.e. accounting manipulation) reduce the surplus because it imposes additional risk on productive effort as well as increases the cost of unproductive actions. Therefore, allowing manipulation increases the cost of incentive contracting required to induce the same level of productive effort. Goldman and Slezak (2006) examine the relation between accounting manipulation and stock-based compensation. They show that stock-based compensation is a double-edged sword because it not only induces productive effort but also incentivizes the manager to engage in manipulation activities. As a consequence, accounting manipulation makes it harder to induce managerial effort. Crocker and Slemrod (2007) examine the relation between compensation contracts contingent on reported earnings and managerial incentive. They show it is impossible to design such a contract that can incentivize the manager to maximize firm profits and to truthfully report these profits. Laux (2014) considers a setting in which long-term project payoffs can be used for contracting purposes. He assumes that the informativeness of the private information observed by the manager does not depend on the productive effort level and shows that allowing manipulation always increases the cost of incentive contracting. Overall, these prior studies show that constraining manipulation via monitoring alleviates effort control problems and reduces the cost of incentive contracting, consistent with conventional wisdom. In the present study, I examine the relationships between a monitoring system, shareholder value, and managerial rents under different contracting environments and show that the contractibility of investment outcomes affects these relationships. In addition, while prior studies have shown that constraining manipulation via monitoring alleviates effort control problems, I show that it can aggravate, rather than alleviate, these problems.

In addition, this study can be linked to prior literature that shows the benefits of accounting manipulation to shareholders. Arya et al. (1998) consider a setting in which the principal can fire the agent at will and show that allowing managers to manipulate accounting information protects them from being dismissed early and thus may reduce the cost to induce them to accept employment contracts. Similarly, Demski (1998) shows that firms benefit from earnings management that results in income smoothing when managers are allowed to smooth income if and only if he works hard in all periods. Dutta and Gigler (2002) show that it is not always optimal to design the accounting system to prevent accounting manipulation because accounting manipulation makes it easier to elicit truthful forecasts from managers. Considering a trade-off between productive effort and manipulation effort, Demski et al. (2004) show that it may be optimal for principals to facilitate the accounting manipulation process because it reduces agents' manipulation incentives and alleviates effort control problems. Liang (2004) considers an interaction between a risk-neutral principal and a risk-averse agent and shows that manipulation can reduce the variability of compensation across periods and thus reduce the risk premium paid to the agent. Finally, Drymiotes (2008) shows that it may be optimal to allow managers to influence their performance evaluation in order to lower managerial compensation costs. Although these papers show that manipulation can be beneficial to shareholders, the intuitions behind these results are different from the intuition in the present study which argues that the manager manipulates the report to convince shareholders to continue the project and that this manipulation incentive increases in the level of managerial effort. Consequently, manipulation can make it more attractive for the manager to exert high effort, resulting in lower costs of incentive contracting. In addition, unlike prior studies that show the benefits of accounting manipulation to shareholders, this study analyzes the impacts of monitoring on both shareholder value and managerial rents simultaneously in order to provide a better understanding of how shifts in the relative power between shareholders and managers affect monitoring intensity.

Prior literature also shows that accounting manipulation can benefit shareholders through managers' private information. Specifically, Chaney and Lewis (1995) show that managers engage in accounting manipulation activities to signal their private information about the true value of companies. This argument suggests that accounting manipulation can increase the informativeness of accounting reports with respect to firm value and thus can improve investment decisions. In this paper, although the manager's manipulation incentive is similar to signalling behaviors in the sense that the manipulation incentive increases in the effort level, manipulation does not directly benefit shareholders because manipulation always distorts investment efficiency. Rather, I show that this manipulation incentive can benefit shareholders because it can alleviate effort control problems and thus reduce the cost of incentive contracting.

Chapter 3

Model

This chapter outlines the setup of the main model. I consider a model with two risk-neutral players in a firm—a manager and shareholders. The firm has an investment project and the quality of the project depends on the manager's unobservable effort. Thus, in order to induce high managerial effort, shareholders must offer an incentive contract.

3.1 Timing

There are four dates: t_0, t_1, t_2, and t_3. At t_0, a manager and shareholders implement a monitoring system. The intensity of the monitoring system is jointly determined by both parties. At t_1, shareholders offer the manager an incentive contract, and the manager chooses an unobservable effort choice that affects project quality. At t_2, the manager privately observes a signal that provides information about project quality and can manipulate it. Shareholders observe potentially manipulated information and decide whether to continue or to liquidate the project. At t_3, an investment outcome is realized. Figure 3.1 depicts the timeline of the model.

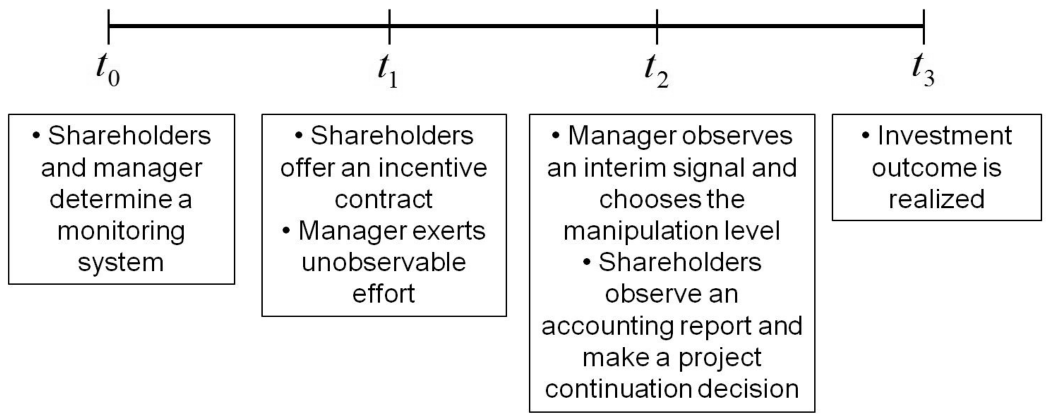

Figure 3.1: Timeline of the Model

3.2 Investment Projects and Productive Effort

The firm has an investment project which can be a high quality project (λ_h) or a low quality project (λ_l). The quality of the project cannot be observed by any parties but can be inferred after observing investment outcomes because a high quality project yields a high outcome of $R > 0$ while a low quality project yields a low outcome of 0. The quality of the project depends on unobservable managerial effort. If the manager exerts high effort (referred to as "a working manager"), he incurs a personal cost of $b > 0$ and the probability that project quality is high is p_h. However, if the manager chooses low effort (referred to as "a shirking manager"), the probability that project quality is high is reduced to p_l, $1 > p_h > p_l > 0$, but he does not incur any personal cost of effort. As is common in agency problem literature, I assume that it is optimal for shareholders to induce the manager to exert high effort. This is the case, for example, when R is sufficiently large or when b is sufficiently small.[1] Figure 3.2 shows how managerial effort affects project quality and investment outcomes.

3.3 Information, Manipulation Activities, and Monitoring Technology

At t_2, the manager privately observes a binary signal, $s \in \{s_h, s_l\}$, that provides information about project quality, λ. The accuracy of the signal is exogenously given and is denoted by $q \in (0.5, 1)$ such that $\Pr(s_h|\lambda_h) = \Pr(s_l|\lambda_l) = q$ and $\Pr(s_l|\lambda_h) = \Pr(s_h|\lambda_l) = (1-q)$.[2] After observing the signal, the manager can choose whether or not to engage in accounting manipulation activities, which distort the information contained in the accounting report, $\theta \in \{\theta_h, \theta_l\}$. If the manager chooses not to manipulate the information, the report is truthful in the sense that when the signal is high (s_h), the report

[1] In equilibrium, the manager always exerts high effort and, therefore, a shirking manager does not exist. Nevertheless, analyzing actions taken by a shirking manager is necessary because shareholders have to design an incentive contract to prevent the manager from exerting low effort.

[2] The assumption that the signal is, on average, unbiased is not crucial for the analysis. The qualitative results in this study continue to hold as long as $\Pr(s_h|\lambda_h) \in (0.5, 1)$ and $\Pr(s_l|\lambda_l) \in (0.5, 1)$. One example is a conservative signal where $\Pr(s_l|\lambda_h) > \Pr(s_h|\lambda_l)$.

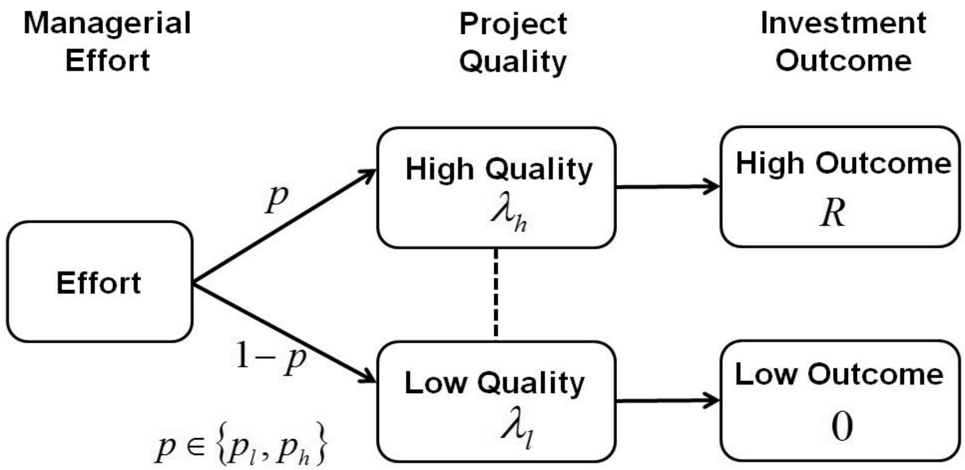

Figure 3.2: Effort and Investment Outcomes

is θ_h and when the signal is low (s_l), the report is θ_l. If, however, the manager privately chooses a manipulation level $m \in [0, 1]$ by incurring a personal cost of $0.5km^2$, the accounting report is distorted (i.e. the report is θ_l when $s = s_h$ and θ_h when $s = s_l$) with probability m and is truthful with probability $1-m$. Figure 3.3 depicts the information environment in this model.

The parameter k represents the monitoring intensity, $k \in [k_{\min}, k_{\max}]$, $k_{\min} > k_0 > 0$ where k_0 is defined in Appendix B.[3] The assumption that

[3]To focus on the effects of monitoring on accounting manipulation, incentive contracting,

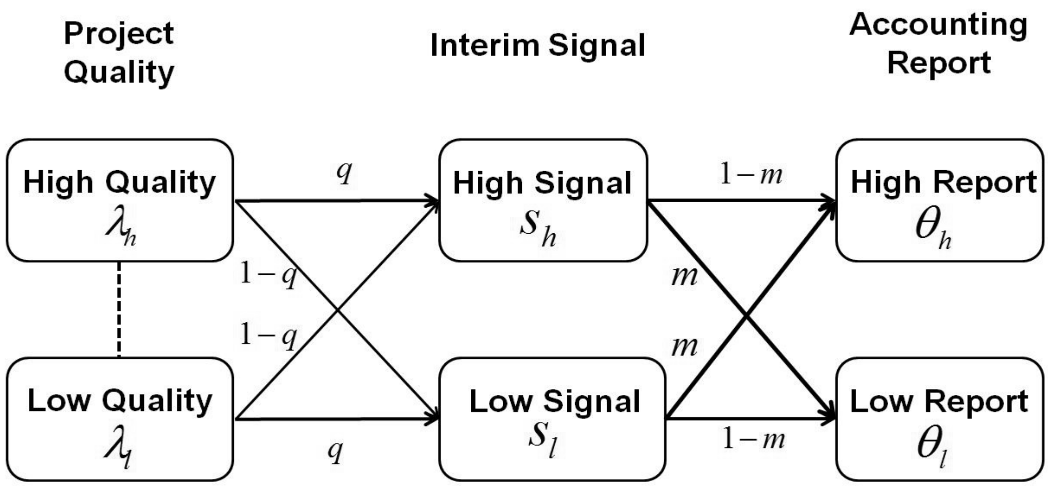

Figure 3.3: Information Environment

$k \geq k_{\min}$ reflects the notion that firms must implement some forms of monitoring to satisfy regulatory requirements. For example, companies must prepare their financial reports under the Generally Accepted Accounting Principles and these reports must be audited by external auditors. In addition, the SEC

shareholder value, and managerial rents, I define monitoring as a mechanism that constrains accounting manipulation activities. Other definitions of monitoring used in prior studies include the ability to identify the manager's ability or type (e.g. Cremer 1995, Hermalin and Weisbach 1998, Laux 2017), the ability to identify the manager's effort level (Huddart 1993), the ability to find a replacement manager (Almazan et al. 2005), and the precision of information (Drymiotes 2007).

requires companies to disclose whether their audit committees include at least one financial expert (SEC 2003). Although these requirements are in place, they represent minimum requirements that firms must satisfy, and firms have discretion in implementing a more intense monitoring system, $k > k_{\min}$. As an example, firms can design a stricter internal control system, include more independent members in their boards of directors, or include more financial experts in their audit committees. The focus of this study is on discretionary monitoring. I assume that monitoring is costless but k is jointly determined by the manager and shareholders at t_0.[4] The assumption that both the manager and shareholders can influence monitoring intensity can be motivated by the observation that shareholders do not have full control over a monitoring system, as evidenced by a substantial role of management in appointing directors (Rosenstein and Wyatt 1990). To determine the optimal monitoring system, the manager proposes his preferred monitoring intensity, k_M, while shareholders propose their preferred monitoring system, k_S. The implemented monitoring intensity is $k = \alpha k_M + (1-\alpha) k_S$ where $\alpha \in (0,1)$ represents the relative degree of managerial influence over a monitoring system. Once the monitoring system is implemented, it remains in place until t_2, after the accounting system generates the accounting report. This assumption reflects the notion that monitoring technology cannot be changed in the short run.

[4]In reality, monitoring is likely costly and the cost of monitoring can be another factor that determines optimal monitoring intensity. I abstract away from costly monitoring to focus on the relationship between the relative degree of managerial influence over a monitoring system and the optimal monitoring intensity.

All variables, except project quality, the signal, the manager's effort, and the manipulation level, are publicly observable.

3.4 Project Continuation Decisions

At t_2, after the accounting system generates the accounting report, shareholders decide whether to continue or to liquidate the project. If the project is continued, the investment outcome, either R or 0, is realized at t_3. In contrast, if the project is liquidated, it yields a liquidation value of L at t_2 and no investment outcome is realized at t_3. To ensure that accounting information is relevant in deciding whether to continue or to liquidate the project, I assume that $p_h \left(R - \frac{b}{(p_h - p_l)q}\right) > L \geq \Pr\left(\lambda_h | s_l, p_h\right) R$. As will become clear later, this assumption implies that shareholders find it optimal to continue the project when $\theta = \theta_h$ and to liquidate it when $\theta = \theta_l$.[5]

3.5 Incentive Contracts

Shareholders offer a compensation contract to induce managerial effort. The pay plan takes the form $W = \left(w\left(\theta_h\right), w\left(\theta_l\right), w\left(R\right), w\left(0\right), w\left(L\right)\right)$. This pay plan is based on contractible information which includes the accounting report, $\theta \in \{\theta_h, \theta_l\}$, the investment outcome (R or 0), and the liquidation value (L). In equilibrium, the project is liquidated when $\theta = \theta_l$, implying that the manager's pay when the accounting report is low is the same as his pay

[5]The proof of the optimal project continuation decision is provided in Appendix B.

when the project is liquidated, $w(\theta_l) = w(L)$. Therefore, the optimal pay plan can be simplified to $W = (w(\theta_h), w(\theta_l), w(R), w(0))$. The manager is protected by limited liability such that all payments must be non-negative, $w(\cdot) \geq 0$. Given the project continuation decision described above, if $\theta = \theta_h$, the manager's pay is either $w(\theta_h) + w(R)$ (if the project yields the high outcome) or $w(\theta_h) + w(0)$ (if the project yields the low outcome), and if $\theta = \theta_l$, the manager receives $w(\theta_l)$. The shareholders' objective is to maximize shareholder value:

$$V = \Pi - C,$$

where Π is expected return from the investment project and C is expected compensation.

Chapter 4

Monitoring and Incentive Contracting: Non-Contractible Investment Outcomes

In this chapter, I show the effects of monitoring on incentive contracting in the benchmark setting in which investment outcomes cannot be used for contracting purposes. The assumption that long-term investment outcomes are not contractible is commonly used in prior literature in earnings management (e.g. Feltham and Xie 1994, Goldman and Slezak 2006, Crocker and Slemrod 2007) and can be motivated by various reasons. For example, investment outcomes may not be realized until far enough in the future such that it is not feasible to offer managerial compensation contracts based on these outcomes. When the investment outcomes are not contractible, the pay plan is based on the interim accounting report, $\theta \in \{\theta_h, \theta_l\}$. Suppose the manager is offered fixed pay, $w(\theta_h) = w(\theta_l)$. If this is the case, the manager will have no incentives to manipulate the accounting report. Although this incentive contract eliminates the manager's incentive to manipulate the report, this contract is not optimal because it also eliminates the manager's incentive to supply high productive effort. Therefore, under the optimal contract, the manager will have an incentive to manipulate the accounting report. The following proposition describes the characteristics of the optimal incentive contract.

Proposition 4.1. *When the investment outcomes are not contractible,*
(i) $w(\theta_h) = k\left(1 - \sqrt{1 - \frac{2b}{k(p_h - p_l)(2q-1)}}\right)$ *and* $w(\theta_l) = 0$*, and*
(ii) the manipulation level is $m = \frac{w(\theta_h)}{k}$.

The results in Proposition 4.1 show the optimal pay plan and the manipulation level when the investment outcomes are not contractible. To maximize the manager's incentive to exert high effort, the contract offers minimum payment to the manager when the interim report is low, $\theta = \theta_l$. Due to the manager's limited liability, it is therefore optimal to offer $w(\theta_l) = 0$ and $w(\theta_h) > 0$.[1] With this optimal pay plan, the manager chooses not to manipulate the report when the signal is high, $s = s_h$, but chooses to distort the information when the signal is low, $s = s_l$. Although the manipulation level is the same regardless of the manager's effort choice, the probability that the manager engages in accounting manipulation activities decreases when the effort level increases.

As monitoring becomes more intense (k increases), it is more costly to manipulate the accounting report. In response, the manager reduces his manipulation level, $\frac{dm}{dk} < 0$. This reduction in m makes shirking an unattractive option for the manager because it becomes much harder to obtain the bonus by shirking when the manipulation opportunity is limited. Constraining manipulation via monitoring therefore increases the attractiveness of exerting high

[1] Throughout this paper, I refer to the manager's pay when the accounting report is high or when the project succeeds as a bonus. An alternative interpretation of this form of contract is a stock option plan in which the option is in the money only when the report is high or when the project yields a high outcome.

effort for the manager and reduces the optimal bonus level required to induce managerial effort, $w(\theta_h)$. The following proposition summarizes this result.

Proposition 4.2. *When the investment outcomes are not contractible, as k increases, the bonus level required to induce high managerial effort and the manipulation level decrease, $\frac{dw(\theta_h)}{dk} < 0$ and $\frac{dm}{dk} < 0$.*

Given the optimal contract and the manipulation level shown in Proposition 4.1, expected compensation, C_{no}, can be written as

$$C_{no} = (\Pr(s_h|p_h) + \Pr(s_l|p_h)\, m)\, w(\theta_h), \tag{4.1}$$

where "*no*" stands for non-contractible outcomes. An increase in k has two effects on expected compensation—a decrease in the bonus level, $\frac{dw(\theta_h)}{dk} < 0$, and a decrease in the likelihood the manager obtains the bonus due to a lower manipulation level, $\frac{dm}{dk} < 0$. Both effects work in the same direction such that an increase in k leads to a decrease in expected compensation, $\frac{dC_{no}}{dk} < 0$.

Similar to (4.1), the manager's expected rent (U_{no}) is

$$U_{no} = \Pr(s_h|p_h)\, w(\theta_h) + \Pr(s_l|p_h)\left(mw(\theta_h) - 0.5km^2\right) - b. \tag{4.2}$$

Substituting m and $w(\theta_h)$ from Proposition 4.1 into (4.2) and rearranging the terms, yields

$$U_{no} = w(\theta_h) - \frac{\Pr(s_l|p_l)\, b}{(p_h - p_l)(2q-1)}. \tag{4.3}$$

Equation (4.3) shows that the manager's expected rent depends on the bonus level, $w(\theta_h)$. Since $w(\theta_h)$ decreases in k, the manager's expected rent also decreases in k. These results can be summarized in the following proposition.

Proposition 4.3. *When the investment outcomes are not contractible, as k increases,*

(i) expected compensation decreases, $\frac{dC_{no}}{dk} < 0$, and

(ii) managerial rents decrease, $\frac{dU_{no}}{dk} < 0$.

The results in Proposition 4.3 are consistent with the conventional view that monitoring reduces expected compensation and managerial rents.

Chapter 5

Monitoring and Incentive Contracting: Contractible Investment Outcomes

In Chapter 4, I show that when investment outcomes are not contractible, monitoring makes it more attractive for the manager to exert high productive effort and thus reduces the cost of incentive contracting. In this chapter, however, I show that this result does not necessarily hold. Specifically, in this chapter, I return to the main assumption outlined in Chapter 3 that investment outcomes can be used for contracting purposes. When investment outcomes are contractible, shareholders can offer compensation contracts based on the accounting report (θ_h and θ_l) and the long-term investment outcome (R and 0). That is, the incentive contract consists of $w(\theta_h)$, $w(\theta_l)$, $w(R)$, and $w(0)$. Given that shareholders continue (liquidate) the project when $\theta = \theta_h$ ($\theta = \theta_l$), if $s = s_l$ and the manager does not manipulate the report, his compensation is $w(\theta_l)$. On the other hand, if $s = s_l$ and the manager successfully manipulates the report, he receives not only the payment when the report is high, $w(\theta_h)$, but also the payment based on the investment outcome, either $w(R)$ or $w(0)$. Therefore, expected compensation of the manager who observes s_l and successfully manipulates the report is

$$w(\theta_h) + \Pr(\lambda_h|s_l, p)\, w(R) + \Pr(\lambda_l|s_l, p)\, w(0).$$

Assume for now, and I will show later, that the following condition holds:

$$w(\theta_h) + \Pr(\lambda_h|s_l, p)\, w(R) + \Pr(\lambda_l|s_l, p)\, w(0) > w(\theta_l) \text{ for } p \in \{p_h, p_l\}. \quad (5.1)$$

Condition (5.1) states that if the manager observes s_l, his expected compensation when he successfully manipulates the report is greater than his pay when he does not manipulate the report, regardless of his effort level. This condition implies that if the manager observes s_h, he will not manipulate the accounting report but if he observes s_l, he will choose the manipulation level, m, that maximizes the following function.

$$\begin{aligned} U_{co}(s_l) &= m\left(w(\theta_h) + \Pr(\lambda_h|s_l, p)\, w(R) + \Pr(\lambda_l|s_l, p)\, w(0)\right) \\ &\quad + (1-m)\, w(\theta_l) - 0.5km^2. \end{aligned}$$

The notation "*co*" refers to contractible outcomes.

Using the first-order condition, the manipulation level is

$$m = \frac{w(\theta_h) + \Pr(\lambda_h|s_l, p)\, w(R) + \Pr(\lambda_l|s_l, p)\, w(0) - w(\theta_l)}{k}. \quad (5.2)$$

I show that when $k \geq k_{\min}$, the optimal contract sets $w(R) > 0$ and $w(\theta_h) = w(\theta_l) = w(0) = 0$.[1] The intuition is as follows. To maximize the

[1] One real-world example of a compensation contract that rewards managers based on long-term investment outcomes is a contract that ties managers' pays to firms' earnings growth.

manager's incentive to choose high effort and to minimize expected compensation, it is optimal to reward the manager only when the outcome is the most informative about managerial effort. Since the investment outcome is directly linked to the manager's effort, it is optimal to reward the manager only when the investment outcome is high, $w(R) > 0$. Setting $w(\theta_h) > 0$ is not optimal because it incentivizes the manager to choose low effort and manipulate the report to obtain the bonus rather than to exert high effort in the first place. Similarly, offering $w(0) > 0$ incentivizes the manager to choose low effort because it is more likely that the project yields the low outcome when he exerts low effort than when he exerts high effort.

Now consider the manager's pay when $\theta = \theta_l$. By offering $w(\theta_l) > 0$, the manager's incentive to exert high effort is weakened because the manager is more likely to have a low interim report when he chooses low effort than when he chooses high effort. Therefore, setting $w(\theta_l) > 0$ increases the bonus level required to induce high effort, $w(R)$, and increases expected compensation. Nevertheless, as will be shown later in Chapter 6, offering $w(\theta_l) > 0$ can be useful because it reduces manipulation incentives and thus improves the efficiency of the project continuation decision. However, when $k \geq k_{\min}$, the cost from an increase in the expected compensation outweighs the benefit from the improvement in the project continuation decision efficiency, suggesting that it is not optimal to reward the manager when $\theta = \theta_l$, $w(\theta_l) = 0$.[2]

[2] To my knowledge, no prior empirical studies document the role of ex ante severance agreements (similar to $w(\theta_l)$ in this model) in reducing manipulation incentives. This lack

Substituting $w(\theta_h) = w(\theta_l) = w(0) = 0$ from the optimal contract into (5.2), we obtain the following manipulation level.

$$m = \frac{\Pr(\lambda_h|s_l, p)\, w(R)}{k}. \tag{5.3}$$

The following proposition summarizes the optimal contract and the manipulation level when the investment outcomes are contractible.

Proposition 5.1. *When the investment outcomes are contractible,*
(i) $w(R) = k\left(\frac{-(p_h-p_l)q+\sqrt{(p_h-p_l)^2q^2+\frac{2b(1-q)(p_h\Pr(\lambda_h|s_l,p_h)-p_l\Pr(\lambda_h|s_l,p_l))}{k}}}{(1-q)(p_h\Pr(\lambda_h|s_l,p_h)-p_l\Pr(\lambda_h|s_l,p_l))}\right)$, $w(\theta_h) = w(\theta_l) = w(0) = 0$, *and*
(ii) the manipulation level is $m = \frac{\Pr(\lambda_h|s_l,p)w(R)}{k}$.

Proposition 5.1 presents an interesting result regarding management's manipulation incentives. Unlike the result in Proposition 4.1, the manipulation level shown in Proposition 5.1 not only depends on the bonus, $w(R)$, and the monitoring intensity, k, but also depends on the probability that project quality is high when $s = s_l$, $\Pr(\lambda_h|s_l, p)$. When the investment outcomes are contractible, the manager who observes s_l will obtain the bonus if and only if he successfully manipulates the report *and* possesses a high quality project. Due to the unobservability of the true project quality, the manager updates

of empirical evidence is consistent with the argument in Arya et al. (1998) that severance pay is a costly mechanism and is not likely used to reduce manipulation activities. Prior empirical literature shows that firms use ex ante severance agreements to motivate risk taking (Cadman et al. 2016, Rau and Xu 2013, Rusticus 2006) but corporate governance has no effect on the probability of having a severance agreement (Rusticus 2006).

his belief about the probability that the project will yield the high outcome based on the signal and his effort level. Specifically, when $s = s_l$, the probability that the investment outcome is high is greater when the manager chooses high effort than when he chooses low effort. The implication of this result is that, after observing s_l, a working manager will choose a higher manipulation level than a shirking manager, $m_h > m_l$ where $m_h = \frac{\Pr(\lambda_h|s_l,p_h)w(R)}{k}$ and $m_l = \frac{\Pr(\lambda_h|s_l,p_l)w(R)}{k}$. In other words, when the investment outcomes are contractible, the productive effort and the manipulation incentive are complements, rather than substitutes. As a monitoring system becomes more intense, the manipulation level decreases, and it decreases more quickly for a working manager than for a shirking manager, $\frac{dm_h}{dk} < \frac{dm_l}{dk} < 0$. Note that the manager always works in equilibrium and thus the equilibrium manipulation level is m_h. The following lemma summarizes the results with respect to the manipulation level.

Lemma 5.2. *When the investment outcomes are contractible, the manipulation level increases in the effort level, $m_h > m_l$. As k increases, the manipulation level decreases, and it decreases more quickly for m_h than m_l, $\frac{dm_h}{dk} < \frac{dm_l}{dk} < 0$.*

It is now useful to discuss the relationship between manipulation, the project continuation decision, and the optimal incentive contract. Recall that when $\theta = \theta_l$, the project is liquidated and the manager receives nothing, $w(\theta_l) = 0$. If it is not possible to manipulate the report, the project is always liquidated when $s = s_l$. Thus, the manager that possesses a high quality project and observes s_l is unintentionally penalized by the inaccuracy of the signal because he would receive the bonus, $w(R)$, if the project were continued. This penalty discourages the manager from choosing high effort because the manager is more likely to have a high quality project when he exerts high effort than when he chooses low effort. Accounting manipulation ensures the continuity of the project and reduces the likelihood of this penalty. Consequently, accounting manipulation makes it more attractive for the manager to supply high productive effort.

In addition, as shown in Lemma 5.2, the incentive to override the accounting system to convince shareholders to continue the project is stronger for a working manager than for a shirking manager, $m_h > m_l$. As a monitoring system becomes more intense, the manipulation level decreases at a faster rate for m_h than for m_l. This result implies that monitoring reduces the likelihood the project is continued, and this effect is stronger when the manager exerts high effort than when he exerts low effort. Consequently, constraining manipulation via monitoring reduces the attractiveness of working, resulting in an increase in the bonus level required to induce high managerial effort. The following proposition summarizes this result.

Proposition 5.3. *When the investment outcomes are contractible, as k increases, the bonus level required to induce high managerial effort increases,* $\frac{dw(R)}{dk} > 0$.

Proposition 5.3 presents a counter-intuitive result. Generally, the manager's ability to manipulate the accounting report reduces the informativeness of contractible information with respect to managerial effort because it is difficult to determine whether a favorable performance report is a result of managerial effort or a result of manipulation activities, as shown in Proposition 4.2. However, I show that, when the investment outcomes can be used for contracting purposes, the manager's opportunity to manipulate the report increases the informativeness of contractible information with respect to managerial effort, resulting in a decrease in the optimal bonus level.

Although constraining accounting manipulation via monitoring increases the level of bonus required to induce high managerial effort, its effect on expected compensation is less clear. Similar to (4.1), expected compensation when the investment outcomes are contractible can be expressed as

$$C_{co} = \left(p_h q + p_h \left(1 - q\right) m_h\right) w\left(R\right). \tag{5.4}$$

An increase in k has two opposing effects on expected compensation. On the one hand, as monitoring becomes more intense, the manipulation level decreases, resulting in a decrease in the probability that the manager receives the bonus (the negative effect). On the other hand, as shown in Proposition 5.3, an increase in k increases the bonus level (the positive effect). Therefore, the net effect of k on expected compensation is ambiguous.

To better understand the two forces that affect the relationship between monitoring and expected compensation, consider another benchmark case in which manipulation imposes no cost to the manager but the maximum manipulation level is restricted by monitoring, $m = m_0\left(k\right)$ where $\frac{dm_0(k)}{dk} < 0$.

In this case, the manipulation incentive is independent of the effort choice as the manager always chooses the manipulation level $m_0(k)$. With this manipulation incentive, when k is sufficiently high, the optimal bonus level is $w(R) = \frac{b}{(p_h - p_l)(q + (1-q) m_0(k))}$. In addition, expected compensation is

$$C_{m_0(k)} = (p_h q + p_h (1-q) m_0(k)) w(R) = \frac{p_h b}{(p_h - p_l)},$$

which does not depend on the monitoring level, $\frac{dC_{m_0(k)}}{dk} = 0$. This implies that, when there is no relationship between manipulation incentive and effort choice, the effects of monitoring in increasing the bonus level and in decreasing the likelihood that the manager obtains the bonus cancel each other out such that monitoring does not affect expected compensation. Similarly, the manager's expected rent is unaffected by a change in monitoring intensity because (i) monitoring does not affect expected compensation and (ii) manipulation is costless. The following lemma summarizes the results in this benchmark case.

Lemma 5.4. *When the investment outcomes are contractible, manipulation is costless, and the maximum manipulation level is $m_0(k)$, expected compensation is $C_{m_0(k)} = \frac{p_h b}{(p_h - p_l)}$ and managerial rents are $U_{m_0(k)} = \frac{p_l b}{(p_h - p_l)}$. Both expected compensation and managerial rents are independent of the monitoring level, $\frac{dC_{m_0(k)}}{dk} = 0$ and $\frac{dU_{m_0(k)}}{dk} = 0$.*

The results in Lemma 5.4 no longer hold when management's manipulation incentives depend on the effort level. Specifically, the directional effect of monitoring on expected compensation depends on the sign of the following term:

$$p_l\,(m_h - m_l) - (p_h - p_l)\,m_h. \tag{5.5}$$

Condition 5.5 shows that the relation between monitoring and expected compensation is positive when $(m_h - m_l)$ is large or when m_h is small. Recall that, when long-term investment outcomes are contractible, constraining manipulation via monitoring increases the bonus level required to induce high managerial effort, $\frac{dw(R)}{dk} > 0$, but decreases the likelihood the manager receives the bonus due to a decrease in the manipulation level, $\frac{dm_h}{dk} < 0$. When $(m_h - m_l)$ is large, the manager finds it more attractive to exert high managerial effort because the likelihood he obtains the bonus significantly increases when he exerts high effort. Consequently, it is optimal for shareholders to allow the manager to manipulate the report because doing so significantly reduces the bonus level required to induce high managerial effort and thus reduces expected compensation, $\frac{dC_{co}}{dk} > 0$. On the other hand, when $(m_h - m_l)$ is small, allowing manipulation only marginally decreases the bonus level. Therefore, constraining manipulation via monitoring decreases expected compensation because it marginally increases the bonus level but significantly decreases the likelihood the manager obtains the bonus, $\frac{dC_{co}}{dk} < 0$.

Similarly, when m_h is small, the likelihood that the manager obtains the bonus is low. As a result, allowing manipulation reduces expected compensation because the likelihood the manager obtains the bonus only marginally increases, suggesting a positive association between monitoring and expected compensation, $\frac{dC_{co}}{dk} > 0$. In contrast, when m_h is large, shareholders are better off restricting manipulation activities to reduce the likelihood the manager obtains the bonus. Thus, when m_h is large, a monitoring system that constrains accounting manipulation reduces expected compensation, $\frac{dC_{co}}{dk} < 0$. The analysis shows that, holding p_h and q constant, expected compensation decreases in monitoring intensity (Condition (5.5) is negative) when p_l is sufficiently low. However, when p_l is sufficiently high, implementing a strong monitoring system increases expected compensation (Condition (5.5) is positive).

Using (5.3) and (5.4), the manager's expected rent is

$$U_{co} = C_{co} - \Pr\left(s_l|p_h\right)\left(0.5km_h^2\right) - b. \tag{5.6}$$

The manager's expected rent is a function of expected compensation, C_{co}, and expected manipulation cost, $0.5km_h^2$. Consider first the effect of monitoring on expected manipulation cost. As k increases, the *marginal* cost of manipulation increases. This, however, does not imply that *expected* manipulation cost will also increase. Holding other things constant, monitoring increases expected manipulation cost. But other things cannot be held constant. Specifically, the manager responds to an increase in k by reducing the manipulation level, resulting in a decrease in expected manipulation cost. To understand the intuition, consider an extreme case when manipulation is prohibitively costly, $k \to \infty$. In this case, the manager will choose not to manipulate the report, $m_h = 0$, suggesting that the manager does not incur any manipulation costs. As k decreases, the manipulation level increases, and so does the expected cost of manipulation incurred by the manager.

Although monitoring always decreases expected manipulation cost, its impact on expected compensation depends on p_l, as described above. When p_l is high, monitoring increases the manager's expected rent because it increases expected compensation and decreases expected manipulation cost. When p_l is low, however, monitoring reduces expected compensation but also reduces expected manipulation cost. Since the manipulation level significantly decreases when k increases and p_l is low, the latter effect always dominates the former such that the manager's expected rent increases in k. Therefore, when the investment outcomes are contractible, the manager's expected rent always increases in the monitoring level. This result is in contrast to the conventional argument that monitoring limits managerial rents. The following proposition summarizes the relationships between monitoring, expected compensation, and managerial rents when the investment outcomes can be used for contracting purposes.

Proposition 5.5. *When the investment outcomes are contractible, as k increases,*

(i) managerial rents increase, $\frac{dU_{co}}{dk} > 0$, and

(ii) holding p_h and q constant, if $p_l < p_l^*$, expected compensation decreases in k, $\frac{dC_{co}}{dk} \leq 0$, and if $p_l \geq p_l^*$, expected compensation increases in k, $\frac{dC_{co}}{dk} \geq 0$.

The threshold p_l^* is shown in Appendix B.

The results in Proposition 5.5 show that when the investment outcomes are contractible, monitoring always increases managerial rents but can increase or decrease expected compensation. It is important to note that the results that monitoring affects expected compensation and managerial rents crucially rely on the assumption that manipulation is costly to the manager. Suppose manipulation is costless such that $k = 0$. In this case, the manager's communication is unrestricted and the revelation principle holds. As a consequence, shareholders will choose one the following two options to maximize firm value. The first option is to offer a compensation contract that eliminates manipulation activities. In this contract, the following conditions hold:

$$w\left(\theta_l\right) = \Pr\left(\lambda_h | s_l, p_h\right) w\left(R\right) \text{ and } w\left(\theta_h\right) = w\left(0\right) = 0. \tag{5.7}$$

Substituting (5.7) into (5.2), we obtain $m_h = 0$. This contract allows shareholders to make an efficient project continuation decision (see Chapter 6) but significantly increases the cost of incentive contracting. The second option is to commit to never liquidate the project. With this commitment, the manager no longer has an incentive to manipulate the interim accounting report. Although this commitment eliminates accounting manipulation, investment inefficiency arises because some projects that should have been liquidated are continued. In either option, monitoring has no impact on expected compensation or managerial rents because accounting manipulation does not exist in equilibrium.

Even when the revelation principle does not hold (i.e. manipulation exists in equilibrium), monitoring may not affect expected compensation or managerial rents when manipulation is costless. As shown in Lemma 5.4, when the manager can manipulate the report but the manipulation incentive does not depend on the effort level, there is no association between (i) monitoring and expected compensation or (ii) monitoring and managerial rents.

5.1 Discussion

The analysis thus far relies on the assumption that $k > k_{\min} > k_0$. When this assumption holds, the optimal contract sets $w(R) > 0$ and $w(\theta_h) = w(\theta_l) = w(0) = 0$. The analysis becomes more complicated when this assumption is relaxed (i.e. $k < k_0$). In this discussion section, I offer some conjectures on how the results differ when $k < k_0$.

Suppose $k < k_0$, the manager's manipulation incentive is significantly high. To reduce this manipulation incentive, shareholders optimally set $w(\theta_l) > 0$. Since the manager now receives a positive pay when the accounting report is low, he has less incentive to exert high productive effort. To ensure that the manager is incentivized to supply high productive effort, shareholders must increase the bonus offered to the manager when the long-term investment outcome is high, $w(R)$. This analysis suggests that it is not optimal for shareholders to choose $k < k_0$ because the only benefit of choosing a low monitoring level is to reduce the bonus level required to induce high managerial effort. In other words, expected compensation when $k < k_0$ is greater than expected compensation when $k > k_0$.

Although choosing $k < k_0$ does not benefit shareholders due to an increase in expected compensation, it can benefit the manager. This is because when $w(\theta_l) > 0$, the manager is able to extract higher rents from the firm. Thus, whether the manager prefers $k < k_0$ or $k > k_0$ depends on how weak the monitoring system can be. If the manager can implement a sufficiently weak monitoring system, it can be optimal for him to choose $k < k_0$. However, if the manager cannot implement a sufficiently weak monitoring system (e.g. due to regulatory requirements or other monitoring mechanisms), it is optimal for him to implement a strong monitoring system ($k = k_{\max}$) because when $k > k_0$, monitoring increases managerial rents, as shown in Proposition 5.5.

Chapter 6

Monitoring and Investment Efficiency

In Chapter 4 and 5, I show how a monitoring system that constrains accounting manipulation activities affects incentive contracting. Although the optimal incentive contract induces the manager to exert high productive effort, it also provides incentives for him to manipulate accounting reports. In this chapter, I examine how manipulation incentives (and a monitoring system that constrains them) affect investment efficiency.

Since $L \geq \Pr(\lambda_h | s_l, p_h) R$, by assumption, it is first-best optimal to liquidate the project when $s = s_l$. In addition, the following assumption outlined in Chapter 3

$$p_h \left(R - \frac{b}{(p_h - p_l) q} \right) > L$$

implies that it is first-best optimal to continue the project when $s = s_h$. Given that shareholders find it optimal to continue the project when $\theta = \theta_h$ and to liquidate it when $\theta = \theta_l$, if the manager does not manipulate the report, the first-best project continuation decision is achieved as the project is always continued when $s = s_h$ and is always liquidated when $s = s_l$. Accounting manipulation distorts the information contained in the accounting report and thus distorts investment efficiency. As shown in Chapter 4 and Chapter 5, the manager has an incentive to engage in manipulation activities when $s = s_l$ but does not manipulate the report when $s = s_h$. Consequently, investment inefficiency arises when $s = s_l$ and the manager successfully manipulates the accounting report. Using this argument, the project's expected return, Π, can be expressed as follows:

$$\Pi = p_h q R + \Pr(s_l|p_h) L - \Pr(s_l|p_h) m (L - \Pr(\lambda_h|s_l, p_h) R). \tag{6.1}$$

The first part of (6.1), $p_h q R + \Pr(s_l|p_h) L$, is the project's expected return when the project is continued if and only if $s = s_h$ (the first-best expected return). The second part of (6.1), $\Pr(s_l|p_h) m (L - \Pr(\lambda_h|s_l, p_h) R)$, is the expected cost of investment inefficiency, where $\Pr(s_l|p_h)$ is the probability that $s = s_l$, m is the manipulation level, and $(L - \Pr(\lambda_h|s_l, p_h) R)$ is the opportunity cost of continuing a project that should have been liquidated.

As monitoring becomes more intense, the manipulation level decreases, and the probability that shareholders make the inefficient project continuation decision decreases. The impact of monitoring on the overall reduction in expected cost of investment inefficiency depends on the opportunity cost of inefficient project continuation decisions, $(L - \Pr(\lambda_h|s_l, p_h) R)$. Specifically, the opportunity cost of making inefficient project continuation decisions increases in L. Consider an extreme case when L is very low, $L = \lim_{\varepsilon \to 0^+} (\Pr(\lambda_h|s_l, p_h) R + \varepsilon)$. In this case, the opportunity cost of continuing a project that should have been liquidated is very low and therefore constraining manipulation via monitoring improves the project's expected return only by a small margin. As L increases, the opportunity cost of making the incorrect project continuation decision increases. Consequently, a monitoring system that constrains manipulation activities has a larger impact on the overall investment efficiency when L is high than when L is low. The following proposition summarizes the results in this chapter.

Proposition 6.1. *As k increases, investment efficiency and the project's expected return increase, $\frac{d\Pi}{dk} > 0$. This effect is stronger when the opportunity cost of making inefficient project continuation decisions increases, $\frac{d^2\Pi}{dLdk} > 0$.*

Chapter 7

Optimal Monitoring System

Having analyzed the effects of monitoring on optimal incentive contracts and investment efficiency, in this chapter, I derive the optimal monitoring system and show the effect of the relative power in influencing a monitoring system between managers and shareholders on optimal monitoring intensity.

When the investment outcomes are not contractible, monitoring increases shareholder value because it reduces expected compensation (Proposition 4.3) as well as increases investment efficiency (Proposition 6.1). Therefore, shareholders, who wish to maximize shareholder value, prefer an intense monitoring system, $k_S = k_{\max}$. In contrast, the manager, who wishes to maximize his rents, prefers a weak monitoring system, $k_M = k_{\min}$, because monitoring decreases his expected rent (Proposition 4.3). Since the manager and shareholders prefer a different monitoring system, the implemented monitoring intensity is

$$k_{no}^{*} = \alpha k_{\min} + (1 - \alpha)\, k_{\max}.$$

As the degree of managerial influence over a monitoring system, α, increases, the level of monitoring declines. This result is consistent with the conventional view that managerial power in influencing a monitoring system is negatively associated with monitoring intensity. The following proposition summarizes this result.

Proposition 7.1. *When the investment outcomes are not contractible, the implemented monitoring system is* $k^*_{no} = \alpha k_{\min} + (1-\alpha)\, k_{\max}$. *This monitoring intensity decreases in the degree of managerial influence over a monitoring system,* $\frac{dk^*_{no}}{d\alpha} < 0$.

When shareholders can use the investment outcomes for contracting purposes, however, these results no longer hold. The results in Proposition 5.5 show that the manager's expected rent increases in monitoring intensity. Consequently, the manager always prefers an intense monitoring system, $k_M = k_{\max}$. Shareholders may agree or disagree with the manager regarding the monitoring technology. When p_l is sufficiently low, an increase in k not only reduces expected compensation (Proposition 5.5) but also improves investment efficiency (Proposition 6.1), resulting in an increase in shareholder value. Therefore, when p_l is sufficiently low, shareholders also prefer an intense monitoring system, $k_S = k_{\max}$. Since both the manager and shareholders prefer intense monitoring, $k_{\max}$ is implemented and the relative power between the manager and shareholders has no impact on the optimal monitoring system.

When p_l is sufficiently high, monitoring increases both investment efficiency and expected compensation. The net effect of monitoring on shareholder value depends on the strength of these two forces. When L is high, the former effect dominates the latter such that monitoring increases shareholder value. Thus, when both p_l and L are high, shareholders prefer intense monitoring, $k_S = k_{\max}$, which is consistent with the manager's preference. As a result, the implemented monitoring is $k_{\max}$. Note that in this case, shareholders prefer intense monitoring although monitoring increases expected compensation. Thus, a positive association between monitoring and expected compensation does not necessarily imply that shareholders prefer a weak monitoring system.

Finally, when p_l is sufficiently high and L is low, the effect of monitoring in increasing expected compensation dominates its effect in improving investment efficiency such that monitoring reduces shareholder value. Therefore, shareholders prefer weak monitoring while the manager prefers intense monitoring. The implemented monitoring is $k_{co}^* = \alpha k_{\max} + (1-\alpha)\, k_{\min}$, implying that managerial power in influencing a monitoring system is positively associated with monitoring intensity, $\frac{dk_{co}^*}{d\alpha} = k_{\max} - k_{\min} > 0$. These results are in sharp contrast to the conventional argument that monitoring benefits shareholders and imposes costs on managers. Instead, these results show that when both managers and shareholders can influence a monitoring system, managers will attempt to implement a strong system while shareholders will try to weaken it. These results can be summarized as follows.

Proposition 7.2. *When the investment outcomes are contractible,*

(i) if $p_l < p_l^*$, the implemented monitoring technology is $k_{co}^* = k_{\max}$,

(ii) if $p_l \geq p_l^*$ and $L \geq L^*$, the implemented monitoring technology is $k_{co}^* = k_{\max}$, and

(iii) if $p_l \geq p_l^*$ and $L < L^*$, the implemented monitoring technology is $k_{co}^* =$

$\alpha k_{\max} + (1 - \alpha) k_{\min}$*, and this monitoring intensity increases in the degree of managerial influence over a monitoring system,* $\frac{dk^*_{co}}{d\alpha} > 0$.

The threshold L^* is defined in Appendix B.

The results in part (i) and (ii) of Proposition 7.2 show that monitoring can increase shareholder value and managerial rents simultaneously. The intuition behind this result is that monitoring reduces the deadweight loss associated with expected manipulation cost incurred by the manager as well as the cost of inefficient investment decisions. Therefore, when the gain from the reduction in this deadweight loss is shared between shareholders and managers, both shareholders and managers are better off with increased monitoring. However, in part (iii) of Proposition 7.2, monitoring improves managerial welfare at the expense of shareholders because the effect of monitoring in increasing the cost of incentive contracting outweighs its benefit in improving investment efficiency.

Table 7.1 summarizes the directional effects of monitoring on the manipulation level, investment efficiency, the bonus level, expected compensation, managerial rents, and shareholder value. As shown in Table 7.1, monitoring can either (i) increase shareholder value and decrease managerial rents, (ii) decrease shareholder value and increase managerial rents, or (iii) simultaneously increase both shareholder value and managerial rents. In addition, shareholders may find it optimal to implement a monitoring system that results in a high level of expected compensation and a high level of managerial rents (contractible outcomes, $p_l \geq p_l^*$, $L \geq L^*$) or results in a high level of accounting manipulation (contractible outcomes, $p_l \geq p_l^*$, $L < L^*$). In a similar vein, the manager may prefer a strong monitoring system even when monitoring is negatively associated with expected compensation (contractible outcomes, $p_l < p_l^*$).

Table 7.1: Directional Effects of an Increase in Monitoring Intensity

	As k increases			
	Non-Contractible Outcomes	Contractible Outcomes		
		$p_l < p_l^*$	$p_l \geq p_l^*, L < L^*$	$p_l \geq p_l^*, L \geq L^*$
Manipulation Level (m)	$-$	$-$	$-$	$-$
Investment Efficiency (Π)	$+$	$+$	$+$	$+$
Bonus Level ($w(\theta_h)$ or $w(R)$)	$-$	$+$	$+$	$+$
Expected Compensation (C)	$-$	$-$	$+$	$+$
Managerial Rents (U)	$-$	$+$	$+$	$+$
Shareholder Value (V)	$+$	$+$	$-$	$+$

Chapter 8

Empirical Implications

In this chapter, I provide some empirical implications of the results in this study. The focus of this paper is on a monitoring mechanism that increases the marginal cost of manipulation and thus constrains manipulation activities. Although the model focuses on financial reporting processes in which managers manipulate information in financial statements, it is important to note that the implication of the results in this study can be extended to other settings. For example, one can think of a managerial accounting setting in which a regional manager works on a project and is required to submit interim performance reports to the headquarter while the headquarter can terminate the project. That being said, testing empirical predictions using managerial accounting data can be challenging due to data availability. Therefore, the emphasis of this empirical implication chapter is on financial accounting.

I discuss the empirical implication of the analysis by focusing on two monitoring mechanisms—internal controls and boards of directors. These two mechanisms are appropriate proxies for monitoring in this setting because prior empirical studies have shown that both internal controls and boards of directors reduce manipulation activities. For example, Doyle et al. (2007) document a positive association between internal control weaknesses and estimated accruals that are not realized as cash flows. In addition, Ashbaugh-Skaife et al. (2008) show that firms with internal control deficiencies have lower quality accruals than firms with no internal control deficiencies. Similarly, prior studies show that board independence, audit committee independence, and audit committee financial expertise are negatively associated with abnormal accruals (Klein 2002, Peasnell et al. 2005, Xie et al. 2003) and restatements (Abbott et al. 2004, Agrawal and Chadha 2005, Carcello et al. 2011).

The analysis in Chapter 6 shows the relationship between monitoring and investment efficiency. Specifically, the result in Proposition 6.1 suggests that monitoring intensity is positively associated with investment efficiency. Prior empirical studies document evidence consistent with this result. Cheng et al. (2013) show that firms with material weaknesses in internal controls have less efficient investment and that this effect is mitigated when firms remediate control weaknesses. Similarly, Feng et al. (2015) show that material weaknesses in internal control over financial reporting are negatively associated with return on assets. Finally, McNichols and Stubben (2008) document a positive association between earnings manipulation and overinvestment problems, suggesting that constraining manipulation via monitoring reduces the degrees of overinvestment.

The results in this study also show the relationships between monitoring and expected compensation. When the investment outcomes are not contractible or when they are contractible and the agency friction is not severe (p_l is low), monitoring reduces expected compensation. However, when the investment outcomes are contractible and the agency friction is severe (p_l is high), monitoring increases expected compensation. The result that monitoring can be positively or negatively associated with expected compensation is consistent with mixed findings documented in prior empirical studies. For example, Chhaochharia and Grinstein (2009) show a negative association between monitoring and expected compensation by documenting a decrease in CEO compensation following the implementation of rules requiring independent boards. However, Hoitash et al. (2012) show that CFO compensation decreases in internal control material weaknesses, suggesting a positive association between monitoring and compensation. In addition, Core et al. (1999) show a positive relation between CEO compensation and a percentage of the board composed of outside directors.

A similar argument can be made with respect to the relationships between monitoring and firm value. The results in Proposition 4.3, Proposition 5.5, and Proposition 6.1 predict that monitoring decreases firm value when the investment outcomes are contractible, the agency friction is severe, and the cost of inefficient project continuation decisions is low. For all other firms, monitoring increases firm value. This ambiguous effect of monitoring on firm value is also consistent with mixed empirical evidence shown in prior studies. For example, Bhagat and Black (2002) find no association between the degree of board independence and firm value. In contrast, relying on the argument that small boards are better at monitoring than large boards, Yermack (1996) shows a negative association between board size and firm value. DeFond et al. (2005) examine market reactions after firms appoint financial experts to their audit committees and show that the appointment of accounting financial experts assigned to audit committees has a positive impact on market reactions.

Finally, the results in this study have implications for the relation between manipulation levels and bonus levels. Specifically, both the bonus level ($w(\theta_h)$ or $w(R)$) and the manipulation level are determined by monitoring intensity, k. Furthermore, these two variables affect each other as the bonus affects the manipulation incentive which, in turn, affects the optimal bonus level required to induce high managerial effort. When the investment outcomes are not contractible, I show that monitoring decreases both the bonus level and manipulation incentive (Proposition 4.1), suggesting a positive relation between these two variables. In contrast, when the investment outcomes are contractible, monitoring increases the bonus level but decreases manipulation incentive (Proposition 5.3), suggesting a negative relation between the bonus level and the manipulation level. Therefore, the analysis in this study shows that the relation between manipulation levels and the bonus level can be positive or negative, as summarized in the following Corollary.

Corollary 8.1. *When the investment outcomes are not contractible (are contractible), the relation between manipulation levels and bonus levels is positive (negative).*

Chapter 9

Conclusion

This study shows an unintended consequence of constraining manipulation via monitoring on shareholder value and managerial rents. Contrary to the notion that shareholders are better off and managers are worse off with increased monitoring, this study shows that constraining manipulation via monitoring can reduce shareholder value and increase managerial rents because monitoring can make it harder to induce managerial effort. This result follows because managers have incentives to manipulate accounting information to convince shareholders to continue the project, and these manipulation incentives are stronger when managers exert high productive effort than when they choose low productive effort. Allowing manipulation therefore makes it more attractive for managers to supply high productive effort because the likelihood of obtaining a bonus significantly increases. This result suggests that restricting manipulation via monitoring can increase the cost of incentive contracting. In addition, the analysis shows that an increase in monitoring intensity can be Pareto-optimal, as both shareholders and managers benefit from increased monitoring.

The results of this study suggest many implications that contrast with conventional wisdom. For example, shareholders may prefer a weak monitoring system that leads to a high level of accounting manipulation. Additionally, shareholders may optimally implement a monitoring system that results in a high level of expected compensation and managerial rents. In the same vein, managers may be better off in a monitoring environment where expected compensation is low. Finally, as managerial power over a monitoring system increases, optimal monitoring intensity can remain unaffected or increase rather than decrease.

This study can be extended in several ways. As an example, in this study, the accuracy of information is exogenously given and is publicly observed. Future studies can endogenize this variable or consider cases in which this information is privately observed by the manager or shareholders. Another extension would be to examine multiple roles of monitoring in an organization. In order to focus on the effect of monitoring on accounting information, this study examines one role of monitoring—to constrain accounting manipulation activities. Future research could analyze other roles of monitoring, including learning about project quality or managerial effort, and examine the interaction across various roles.

Appendices

Appendix A

Variable Definitions

λ_h	High quality project
λ_l	Low quality project
R	Long-term investment outcome when the project quality is high
L	Liquidation value
p_h	Probability that the project quality is high given high managerial effort
p_l	Probability that the project quality is high given low managerial effort
b	Cost of high effort
s_h	High interim signal
s_l	Low interim signal
q	Probability that the signal is accurate
θ_h	High accounting report
θ_l	Low accounting report
m	Manipulation level (probability that manipulation is successful)
m_h	Manipulation level when the manager exerts high effort
m_l	Manipulation level when the manager exerts low effort
k	Monitoring intensity (marginal cost of manipulation)
k_M	Monitoring level proposed by the manager
k_S	Monitoring level proposed by shareholders
α	Relative degree of managerial influence over a monitoring system
$w(\theta_h)$	Manager's pay when the accounting report is high
$w(\theta_l)$	Manager's pay when the accounting report is low
$w(R)$	Manager's pay when the long-term investment outcome is high
$w(0)$	Manager's pay when the long-term investment outcome is low

V	Shareholder value
Π	Expected return from the investment project
C	Expected compensation
U	Managerial rents
no	Non-contractible investment outcomes
co	Contractible investment outcomes

Appendix B

Proofs

Proof of Proposition 4.1

Suppose $w(\theta_h) > w(\theta_l)$. If the manager observes s_h, he does not manipulate the report and obtains $w(\theta_h)$. If he observes s_l, he chooses the manipulation level, m, that maximizes the following utility function.

$$U_{no}(s_l) = mw(\theta_h) + (1-m)\,w(\theta_l) - 0.5km^2. \tag{B.1}$$

Taking the first-order condition of (B.1), yields

$$m = \frac{w(\theta_h) - w(\theta_l)}{k}. \tag{B.2}$$

Using (B.1) and (B.2), the incentive compatibility constraint is

$$(\Pr(s_h|p_h) - \Pr(s_h|p_l))\left(w(\theta_h) - w(\theta_l) - 0.5km^2\right) \geq b. \tag{B.3}$$

Substituting (B.2) into (B.3) and solving the inequality, we obtain

$$w(\theta_h) - w(\theta_l) \geq k\left(1 - \sqrt{1 - \frac{2b}{k(p_h - p_l)(2q-1)}}\right).$$

Thus, the optimal contract is as follows.

$$\begin{aligned} w(\theta_h) &= k\left(1 - \sqrt{1 - \frac{2b}{k(p_h - p_l)(2q-1)}}\right) \\ w(\theta_l) &= 0. \end{aligned} \tag{B.4}$$

Using (B.2) and (B.4), the manipulation level is

$$m = \left(1 - \sqrt{1 - \frac{2b}{k\left(p_h - p_l\right)\left(2q - 1\right)}}\right). \blacksquare \tag{B.5}$$

Proof of Proposition 4.2

Using (B.2) and (B.3), $w\left(\theta_h\right)$ can be expressed as follows.

$$w\left(\theta_h\right) = \frac{\frac{b}{(p_h - p_l)(2q-1)} - 0.5km^2}{(1-m)}. \tag{B.6}$$

Taking the first order condition of $w\left(\theta_h\right)$ in (B.6) with respect to k, yields

$$\begin{aligned} \frac{dw\left(\theta_h\right)}{dk} &= -\frac{0.5m^2}{1-m} + \frac{dm}{dk} \cdot \left(\frac{-\left(1-m\right)km + w\left(\theta_h\right)\left(1-m\right)}{\left(1-m\right)^2}\right) \\ &= -\frac{0.5m^2}{1-m} < 0. \end{aligned}$$

In addition, using (B.2), we obtain

$$\frac{dm}{dk} = \frac{\frac{dw(\theta_h)}{dk} - m}{k} < 0$$

because $\frac{dw(\theta_h)}{dk} < 0$, as just established.$\blacksquare$

Proof of Proposition 4.3

Using (4.1), we obtain

$$\begin{aligned} \frac{dC_{no}}{dk} &= \left(\Pr\left(s_h|p_h\right) + \Pr\left(s_l|p_h\right)m\right)\frac{dw\left(\theta_h\right)}{dk} + \Pr\left(s_l|p_h\right)w\left(\theta_h\right)\frac{dm}{dk} \\ &< 0 \text{ because } \frac{dw\left(\theta_h\right)}{dk} < 0 \text{ and } \frac{dm}{dk} < 0. \end{aligned}$$

In addition, using (4.2), we obtain

$$\begin{aligned}
\frac{dU_{no}}{dk} &= \Pr(s_h|p_h)\frac{dw(\theta_h)}{dk} + \frac{\Pr(s_l|p_h)}{2}\left(2km\frac{dm}{dk} + m^2\right) \\
&= (\Pr(s_h|p_h) + \Pr(s_l|p_h)m)\frac{dw(\theta_h)}{dk} - \frac{\Pr(s_l|p_h)m^2}{2} \\
&< 0 \text{ because } \frac{dw(\theta_h)}{dk} < 0. \blacksquare
\end{aligned}$$

Proof of Proposition 5.1

The Lagrangian of the shareholders' optimization problem is as follows:

$$\begin{aligned}
\max G &= p_h qR + \Pr(s_l|p_h)(m_h \Pr(\lambda_h|s_l,p_h)R + (1-m_h)L) \\
&\quad - p_h q(w(\theta_h) + w(R)) - (1-p_h)(1-q)(w(\theta_h) + w(0)) \\
&\quad - \Pr(s_l|p_h)\left(w(\theta_l) + km_h^2\right) \\
&\quad + \mu_1\left(q(w(\theta_h) + w(R)) - (1-q)(w(\theta_h) + w(0)) - \frac{b}{(p_h - p_l)}\right) \\
&\quad + \mu_1\frac{\Pr(s_l|p_h)(w(\theta_l) + 0.5km_h^2)}{(p_h - p_l)} - \mu_1\frac{\Pr(s_l|p_l)(w(\theta_l) + 0.5km_l^2)}{(p_h - p_l)} \\
&\quad + \mu_2((w(\theta_h) + \Pr(\lambda_h|s_l,p_h)w(R) + \Pr(\lambda_l|s_l,p_h)w(0))) \\
&\quad + \mu_3((w(\theta_h) + \Pr(\lambda_h|s_l,p_l)w(R) + \Pr(\lambda_l|s_l,p_l)w(0))) \\
&\quad - \mu_2(w(\theta_l) + m_h k) - \mu_3(w(\theta_l) + m_l k)
\end{aligned}$$

where μ_1 is the Lagrangian multiplier associated with the effort incentive constraint, μ_2 is the multiplier associated with the manipulation constraint when the manager exerts high effort, and μ_3 is the multiplier associated with the manipulation constraint when the manager exerts low effort.

The necessary conditions for a solution include: $\frac{\partial G}{\partial w(i)}w(i) = 0$ for $i \in \{\theta_h, \theta_l, R, 0\}$, and $\frac{\partial G}{\partial m_j}m_j = 0$ for $j \in \{h, l\}$.

Assume that in the optimal solution, $w(R) > 0$ and $w(\theta_l) = 0$. This implies that $m_h > 0$ and $m_l > 0$. Therefore, the optimal solution is determined by $\frac{\partial G}{\partial w(R)} = \frac{\partial G}{\partial m_h} = \frac{\partial G}{\partial m_l} = 0$. Let μ_1^*, μ_2^*, and μ_3^* be the solution to $\frac{\partial G}{\partial w(R)} = \frac{\partial G}{\partial m_h} = \frac{\partial G}{\partial m_l} = 0$, we obtain

$$\begin{aligned}
\mu_1^* &= \frac{(p_h - p_l)(p_h q + 2p_h(1-q)m_h)}{(q(p_h - p_l) + p_h(1-q)m_h - p_l(1-q)m_l)} \\
&\quad - \frac{(p_h - p_l)p_h(1-q)(\Pr(\lambda_h|s_l, p_h)R - L)}{k(q(p_h - p_l) + p_h(1-q)m_h - p_l(1-q)m_l)} \\
\mu_2^* &= \frac{\Pr(s_l|p_h)(\Pr(\lambda_h|s_l, p_h)R - L)}{k} - 2\Pr(s_l|p_h)m_h + \mu_1^* \frac{\Pr(s_l|p_h)m_h}{(p_h - p_l)} \\
\mu_3 &= -\mu_1^* \frac{\Pr(s_l|p_l)m_l}{(p_h - p_l)}.
\end{aligned}$$

Using μ_1^*, μ_2^*, μ_3^*, (5.2), and $w(\theta_l) = 0$, it can be shown that

$$\begin{aligned}
\frac{\partial G}{\partial w(\theta_h)} &= -p_h q - (1-p_h)(1-q) + \mu_1^*(2q-1) + \mu_2^* + \mu_3^* \\
&= \frac{\partial G}{\partial w(0)} - p_h q + \mu_1^* q + \mu_2^* \Pr(\lambda_h|s_l, p_h) + \mu_3^* \Pr(\lambda_h|s_l, p_l) \\
&= \frac{\partial G}{\partial w(0)} + \frac{\partial G}{\partial w(R)} \\
&= \frac{\partial G}{\partial w(0)},
\end{aligned}$$

and

$$\begin{aligned}
\frac{\partial G}{\partial w(0)} &= \frac{(\Pr(\lambda_h|s_l, p_h)R - L)(p_h - p_l)\left(p_h(1-q)^2 + (1-p_h)q^2\right)}{k(q(p_h - p_l) + p_h(1-q)m_h - p_l(1-q)m_l)} \\
&\quad + \frac{(\Pr(\lambda_h|s_l, p_h)R - L)(p_h - p_l)q(1-q)m_l}{k(q(p_h - p_l) + p_h(1-q)m_h - p_l(1-q)m_l)} \\
&\quad - \frac{(p_h q + 2p_h(1-q)m_h)(1-q)(p_h - p_l)}{(q(p_h - p_l) + p_h(1-q)m_h - p_l(1-q)m_l)} \\
&\quad + \frac{(p_h q + 2p_h(1-q)m_h)((1-p_h)qm_h - (1-p_l)qm_l)}{(q(p_h - p_l) + p_h(1-q)m_h - p_l(1-q)m_l)} \\
&\quad - (1-p_h)(1-q) - 2(1-p_h)qm_h,
\end{aligned}$$

which is negative for all $0 < p_l < p_h < 1$ and $q \in (0.5, 1)$. Therefore, it is optimal to set $w(0) = 0$ and $w(\theta_h) = 0$.

In addition, it can be shown that

$$\frac{\partial G}{\partial w(\theta_l)} = -\Pr(s_l|p_h) + \mu_1^* \frac{\Pr(s_h|p_l) - \Pr(s_h|p_h)}{(p_h - p_l)} - \mu_2^* - \mu_3^*$$

and

$$\begin{aligned} \lim_{k\to\infty} \frac{\partial G}{\partial w(\theta_l)} &= -\Pr(s_l|p_h) + \frac{p_h(\Pr(s_h|p_l) - \Pr(s_h|p_h))}{(p_h - p_l)} \\ &= -q < 0 \end{aligned}$$

whereas $\frac{d}{dk}\left(\frac{\partial G}{\partial w(\theta_l)}\right) < 0$ for all $0 < p_l < p_h < 1$ and $q \in (0.5, 1)$. These results suggest that there exists k_0 such that when $k \geq k_0$, the optimal contract sets $w(\theta_l) = 0$.

Given that $w(R) > 0$ and $w(\theta_h) = w(\theta_l) = w(0) = 0$, the incentive compatibility constraint can be written as follows.

$$p_h q w(R) + \Pr(s_l|p_h)\left(0.5k(m_h)^2\right) - b \geq p_l q w(R) + \Pr(s_l|p_l)\left(0.5k(m_l)^2\right). \tag{B.7}$$

Substituting (5.3) into (B.7) and solving the inequality, we obtain

$$w(R) \geq k\left(\frac{-(p_h - p_l)q + \sqrt{(p_h - p_l)^2 q^2 + \frac{2b(1-q)(p_h \Pr(\lambda_h|s_l,p_h) - p_l \Pr(\lambda_h|s_l,p_l))}{k}}}{(1-q)(p_h \Pr(\lambda_h|s_l,p_h) - p_l \Pr(\lambda_h|s_l,p_l))}\right).$$

Therefore, the optimal bonus level is

$$w(R) = k\left(\frac{-(p_h - p_l)q + \sqrt{(p_h - p_l)^2 q^2 + \frac{2b(1-q)(p_h \Pr(\lambda_h|s_l,p_h) - p_l \Pr(\lambda_h|s_l,p_l))}{k}}}{(1-q)(p_h \Pr(\lambda_h|s_l,p_h) - p_l \Pr(\lambda_h|s_l,p_l))}\right),$$

and the manipulation level is

$$m_h = \frac{\Pr\left(\lambda_h | s_l, p_h\right) w\left(R\right)}{k}.\blacksquare \tag{B.8}$$

Proof of Lemma 5.2

Using (5.3), the manipulation level is

$$m = \frac{\Pr\left(\lambda_h | s_l, p\right) w\left(R\right)}{k}.$$

Since $\Pr\left(\lambda_h | s_l, p_h\right) > \Pr\left(\lambda_h | s_l, p_l\right)$, it follows that $m_h > m_l$.

Using (B.7), $w\left(R\right)$ can be expressed as follows.

$$w\left(R\right) = \frac{b + \Pr\left(s_l | p_l\right)\left(0.5k\left(m_l\right)^2\right) - \Pr\left(s_l | p_h\right)\left(0.5k\left(m_h\right)^2\right)}{\left(p_h - p_l\right) q}. \tag{B.9}$$

Using (B.9), we obtain

$$\frac{dw\left(R\right)}{dk} = \frac{\Pr\left(s_l | p_l\right)\left(\frac{1}{2}\left(2km_l\frac{dm_l}{dk} + m_l^2\right)\right) - \Pr\left(s_l | p_h\right)\left(\frac{1}{2}\left(2km_h\frac{dm_h}{dk} + m_h^2\right)\right)}{\left(p_h - p_l\right) q}. \tag{B.10}$$

Substituting $\frac{dm_l}{dk} = \frac{\Pr(\lambda_h | s_l, p_l)\frac{dw(R)}{dk} - m_l}{k}$ and $\frac{dm_h}{dk} = \frac{\Pr(\lambda_h | s_l, p_h)\frac{dw(R)}{dk} - m_h}{k}$ into (B.10) and solving for $\frac{dw(R)}{dk}$, yields

$$\frac{dw\left(R\right)}{dk} = \frac{\Pr\left(s_l | p_h\right)\frac{m_h^2}{2} - \Pr\left(s_l | p_l\right)\frac{m_l^2}{2}}{\left(p_h - p_l\right) q + p_h\left(1 - q\right) m_h - p_l\left(1 - q\right) m_l}. \tag{B.11}$$

Using (5.3), we obtain

$$\frac{dm_h}{dk} = \frac{\Pr\left(\lambda_h | s_l, p_h\right)\frac{dw(R)}{dk} - m_h}{k}. \tag{B.12}$$

Substituting $\frac{dw(R)}{dk}$ from (B.11) into (B.12), yields

$$\begin{aligned}\frac{dm_h}{dk} &= \frac{1}{k}\left(\frac{-p_h\left(1-q\right)\frac{m_h^2}{2}+p_l\left(1-q\right)\frac{m_l m_h}{2}-\left(p_h-p_l\right)qm_h}{\left(p_h-p_l\right)q+p_h\left(1-q\right)m_h-p_l\left(1-q\right)m_l}\right) \\ &= \frac{1}{k}\left(\frac{-\frac{(1-q)m_h}{2}\left(p_h m_h-p_l m_l\right)-\left(p_h-p_l\right)qm_h}{\left(p_h-p_l\right)q+p_h\left(1-q\right)m_h-p_l\left(1-q\right)m_l}\right)<0. \quad \text{(B.13)}\end{aligned}$$

Similarly, using (5.3), we obtain

$$\frac{dm_l}{dk}=\frac{\Pr\left(\lambda_h|s_l,p_l\right)\frac{dw(R)}{dk}-m_l}{k}. \quad \text{(B.14)}$$

Substituting $\frac{dw(R)}{dk}$ from (B.11) into (B.14), yields

$$\begin{aligned}\frac{dm_l}{dk} &= \frac{1}{k}\left(\frac{-p_h\left(1-q\right)\frac{m_h m_l}{2}+p_l\left(1-q\right)\frac{m_l^2}{2}-\left(p_h-p_l\right)qm_h}{\left(p_h-p_l\right)q+p_h\left(1-q\right)m_h-p_l\left(1-q\right)m_l}\right) \\ &= \frac{1}{k}\left(\frac{-\frac{(1-q)m_l}{2}\left(p_h m_h-p_l m_l\right)-\left(p_h-p_l\right)qm_l}{\left(p_h-p_l\right)q+p_h\left(1-q\right)m_h-p_l\left(1-q\right)m_l}\right)<0. \quad \text{(B.15)}\end{aligned}$$

In addition, using (B.13) and (B.15), it follows that $\frac{dm_h}{dk}<\frac{dm_l}{dk}$ because $m_h>m_l$.■

Proof of Proposition 5.3

Substituting $m_h=\frac{\Pr(\lambda_h|s_l,p_h)w(R)}{k}$ and $m_l=\frac{\Pr(\lambda_h|s_l,p_l)w(R)}{k}$ into (B.11), yields

$$\frac{dw\left(R\right)}{dk}=\frac{\left(p_h m_h-p_l m_l\right)\left(1-q\right)w\left(R\right)}{2k\left(\left(p_h-p_l\right)q+p_h\left(1-q\right)m_h-p_l\left(1-q\right)m_l\right)},$$

which is positive because $m_h>m_l$ (Lemma 5.2).■

Proof of Lemma 5.4

Suppose $w(R) > 0$ and $w(\theta_h) = w(\theta_l) = w(0) = 0$. The incentive compatibility constraint is

$$(p_h q + p_h (1-q) m_0(k)) w(R) - b \geq (p_l q + p_l (1-q) m_0(k)) w(R). \quad \text{(B.16)}$$

Solving (B.16), we obtain

$$w(R) = \frac{b}{(p_h - p_l)(q + (1-q) m_0(k))}.$$

Expected compensation is

$$C_{m_0(k)} = (p_h q + p_h (1-q) m_0(k)) w(R) = \frac{p_h b}{(p_h - p_l)},$$

and the manager's expected rent is

$$U_{m_0(k)} = C_{m_0(k)} - b = \frac{p_l b}{(p_h - p_l)}.$$

In addition, $\frac{dC_{m_0(k)}}{dk} = 0$ and $\frac{dU_{m_0(k)}}{dk} = 0$.■

Proof of Proposition 5.5

Using (5.4), we obtain

$$\begin{aligned}
\frac{dC_{co}}{dk} &= (p_h q + p_h (1-q) m_h) \frac{dw(R)}{dk} + p_h (1-q) w(R) \frac{dm_h}{dk} \\
&= (p_h q + 2p_h (1-q) m_h) \frac{dw(R)}{dk} - \Pr(s_l | p_h) m_h^2. \quad \text{(B.17)}
\end{aligned}$$

Substituting $\frac{dw(R)}{dk}$ from (B.11) into (B.17) and rearranging the terms, yields

$$\begin{aligned}
\frac{dC_{co}}{dk} &= \frac{\Pr(s_l|p_h)\, m_h q \left(\frac{p_l(m_h - m_l)}{2} - \frac{(p_h - p_l) m_h}{2}\right)}{(p_h - p_l)\, q + p_h (1-q)\, m_h - p_l (1-q)\, m_l} \\
&= \frac{\Pr(s_l|p_h)\, m_h q \left(\frac{(p_h - p_l)(1-q)(2p_h p_l q + p_l q - p_h p_l - p_h q) w(R)}{2k \Pr(s_l|p_h) \Pr(s_l|p_l)}\right)}{(p_h - p_l)\, q + p_h (1-q)\, m_h - p_l (1-q)\, m_l}.
\end{aligned}$$

Define $p_l^* \equiv \frac{p_h q}{p_h(2q-1)+q}$. When $p_l \geq p_l^*$, $(2p_h p_l q + p_l q - p_h p_l - p_h q) \geq 0$, and $\frac{dC_{co}}{dk} \geq 0$. In contrast, when $p_l < p_l^*$, $(2p_h p_l q + p_l q - p_h p_l - p_h q) < 0$, and $\frac{dC_{co}}{dk} < 0$.

Using (5.6), we obtain

$$\begin{aligned}
\frac{dU_{co}}{dk} &= p_h q \frac{dw(R)}{dk} + \Pr(s_l|p_h) \left(m_h \Pr(\lambda_h|s_l, p_h) \frac{dw(R)}{dk} - \frac{m_h^2}{2} \right) \\
&= (p_h q + p_h (1-q)\, m_h) \frac{dw(R)}{dk} - \Pr(s_l|p_h) \frac{m_h^2}{2}. \qquad \text{(B.18)}
\end{aligned}$$

Substituting $\frac{dw(R)}{dk}$ from (B.11) into (B.18) and rearranging the terms, yields

$$\frac{dU_{co}}{dk} = \frac{p_h p_l q (1-q)\, w(R)\, (m_h - m_l)}{2k \left((p_h - p_l)\, q + p_h (1-q)\, m_h - p_l (1-q)\, m_l\right)} > 0. \blacksquare$$

Proof of Proposition 6.1

Using (6.1), we obtain

$$\begin{aligned}
\frac{d\Pi}{dk} &= \frac{\partial \Pi}{\partial m} \cdot \frac{dm}{dk} \\
&= -\Pr(s_l|p_h)\, (L - \Pr(\lambda_h|s_l, p_h)\, R) \cdot \frac{dm}{dk},
\end{aligned}$$

which is positive because $(L - \Pr(\lambda_h|s_l, p_h) R) > 0$, by assumption, and $\frac{dm}{dk} < 0$ (Proposition 4.2 and Lemma 5.2). In addition,

$$\frac{d^2\Pi}{dLdk} = -\Pr(s_l|p_h)\frac{dm}{dk} > 0,$$

because $\frac{dm}{dk} < 0$.■

Proof of Proposition 7.1

It follows from the results in Proposition 4.3 that $k_M = k_{\min}$. In addition, shareholder value (V) can be expressed as follows.

$$V = \Pi - C_{no}.$$

Since $\frac{d\Pi}{dk} > 0$ (Proposition 6.1) and $\frac{dC_{no}}{dk} < 0$ (Proposition 4.3), it follows that $\frac{dV}{dk} > 0$ and $k_S = k_{\max}$. Thus, $k^*_{no} = \alpha k_{\min} + (1-\alpha) k_{\max}$. In addition, $\frac{dk^*_{no}}{d\alpha} = k_{\min} - k_{\max} < 0$.■

Proof of Proposition 7.2

L^* is defined as follows.

$$L^* = \Pr(\lambda_h|s_l, p_h) R - \frac{\frac{dC}{dk}}{\Pr(s_l|p_h)\frac{dm_h}{dk}}.$$

Note that when $p_l > p^*_l$, we obtain $L^* > \Pr(\lambda_h|s_l, p_h) R$ because $\frac{dC}{dk} > 0$ and $\frac{dm_h}{dk} < 0$.

It follows from the results in Proposition 5.5 that $k_M = k_{\max}$. In addition, shareholder value (V) is

$$V = \Pi - C_{co},$$

where $\frac{d\Pi}{dk} > 0$ (Proposition 6.1).

Part (i): When $p < p_l^*$, $\frac{dC_{co}}{dk} \leq 0$ (Proposition 5.5). Thus, it follows that $\frac{dV}{dk} > 0$ and $k_S = k_{\max}$. Since $k_M = k_S$, the optimal monitoring is $k_{co}^* = k_{\max}$.

Part (ii): When $p \geq p_l^*$ and $L \geq L^*$, it follows that

$$\frac{dV}{dk} = \Pr(s_l|p_h)\left((\lambda_h|s_l,p_h)R - L\right) \cdot \frac{dm_h}{dk} - \frac{dC_{co}}{dk} \geq 0.$$

Thus, $k_s = k_{\max}$ and the optimal monitoring is $k_{co}^* = k_{\max}$.

Part (iii): When $p \geq p_l^*$ and $L < L^*$, it follows that

$$\frac{dV}{dk} = \Pr(s_l|p_h)\left((\lambda_h|s_l,p_h)R - L\right) \cdot \frac{dm_h}{dk} - \frac{dC_{co}}{dk} < 0.$$

Thus, $k_s = k_{\min}$ and the optimal monitoring is $k_{co}^* = \alpha k_{\max} + (1-\alpha) k_{\min}$, which increases in α because $\frac{dk_{co}^*}{d\alpha} = k_{\max} - k_{\min} > 0$.■

Proof that shareholders find it optimal to continue (to liquidate) the project when $\theta = \theta_h$ ($\theta = \theta_l$).

When the investment outcomes are not contractible:

The optimal contract sets $w(\theta_h) > 0$ and $w(\theta_l) = 0$.

Suppose $\theta = \theta_l$. Expected shareholder value if the project is continued is $\Pr(\lambda_h|s_l,p_h)R - w(\theta_l) = \Pr(\lambda_h|s_l,p_h)R$. If the project is liquidated, expected shareholder value is $L - w(\theta_l) = L$. Therefore, it is optimal to liquidate the project because $L \geq \Pr(\lambda_h|s_l,p_h)R$, by assumption.

Suppose $\theta = \theta_h$. Expected shareholder value if the project is continued is

$$\begin{aligned} & \left(\frac{p_h q + p_h (1-q) m}{p_h q + (1-p_h)(1-q) + (p_h (1-q) + (1-p_h) q) m} \right) R - w(\theta_h) \\ \geq & \left(\frac{p_h q + p_h (1-q)}{p_h q + (1-p_h)(1-q) + (p_h (1-q) + (1-p_h) q)} \right) R - w(\theta_h) \\ = & \; p_h R - w(\theta_h). \end{aligned}$$

If the project is liquidated, expected shareholder value is $L - w(\theta_h)$. Therefore, it is optimal to continue the project because the assumption

$$p_h \left(R - \frac{b}{(p_h - p_l) q} \right) > L$$

implies $p_h R > L$.

When the investment outcomes are contractible:

The optimal contract sets $w(R) > 0$ and $w(\theta_h) = w(\theta_l) = w(0) = 0$.

Suppose $\theta = \theta_l$. Expected shareholder value if the project is continued is $\Pr(\lambda_h | s_l, p_h)(R - w(R))$. If the project is liquidated, expected shareholder value is $L - w(\theta_l) = L$. Therefore, it is optimal to liquidate the project because the assumption $L \geq \Pr(\lambda_h | s_l, p_h) R$ implies $L > \Pr(\lambda_h | s_l, p_h)(R - w(R))$.

Suppose $\theta = \theta_h$. Expected shareholder value if the project is continued is

$$
\begin{aligned}
& \left(\frac{p_h q + p_h (1-q) m_h}{p_h q + (1-p_h)(1-q) + (p_h (1-q) + (1-p_h) q) m_h}\right)(R - w(R)) \\
\geq & \left(\frac{p_h q + p_h (1-q)}{p_h q + (1-p_h)(1-q) + (p_h (1-q) + (1-p_h) q)}\right)(R - w(R)) \\
= & \; p_h (R - w(R)) \\
> & \; p_h \left(R - \lim_{k \to k_{\max}} w(R)\right) \\
> & \; p_h \left(R - \lim_{k \to \infty} w(R)\right),
\end{aligned}
$$

because $\frac{dw(R)}{dk} > 0$ (Proposition 5.3) and $k_{\max} < \infty$.

Using $w(R) = \frac{b + \Pr(s_l|p_l)\left(0.5km_l^2\right) - \Pr(s_l|p_h)\left(0.5km_h^2\right)}{(p_h - p_l)q}$ in (B.9), it follows that $\lim_{k \to \infty} w(R) = \frac{b}{(p_h - p_l)q}$. If the project is liquidated, expected shareholder value is $L - w(\theta_l) = L$. Therefore, it is optimal to continue the project because $p_h \left(R - \frac{b}{(p_h - p_l)q}\right) > L$, by assumption.■

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Vita

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